SESSIONS

SPACE PROPULSION SYMPOSIUM

C4.1. Propulsion Systems I (Monday PM)
Liquid Rocket Engines

C4.2. Propulsion Systems II (Tuesday AM)
Solid and Hybrid Propulsion

C4.3. Propulsion Technology I (Wednesday AM)
Components for Propulsion

C4.5. Propulsion Technology II (Thursday AM)
Technical focus – Students & Young professionals

C4.10. Propulsion Technology III (Friday PM)
All science and technologies supporting topics

C4.4. Electric Propulsion (Wednesday PM)
All aspects of Electric Propulsion

C4.7. Advanced & Nuclear Propulsion (Friday AM)
Joint session with Space Power Symposium - C3.5

C4.9. Hypersonic and Combined Cycle Propulsion
(Tuesday PM)

C4.6. New Missions (Thursday PM)
Enabled by New Propulsion Technology and Systems

C4.8. Small Satellites Propulsion (Friday PM)
Joint session between IAA & IAF – B4.5A

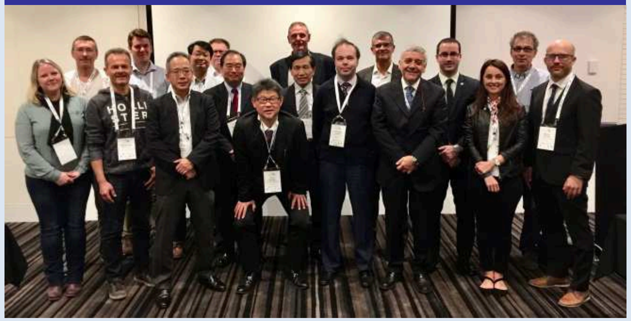
C4.IP Interactive Presentations (permanent)
All aspects of Propulsion

TEAM GERMANY SUPPORTS IAC 69TH INTERNATIONAL ASTRONAUTICAL CONGRESS BREMEN | 1-5 OCTOBER 2018 #INVOLVING EVERYONE

CONTACTS

SPACE PROPULSION SYMPOSIUM

Join Space Propulsion Committee
if willing to contribute to propulsion community



Committee meeting during IAC 2017

Committee objectives:

- Promote propulsion science & technologies
- Build a network of experts

Chair Committee:

- **Dr. Toru Shimada**, Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency, Japan;
- **Dr. Helen Webber**, Reaction Engines Ltd., United Kingdom;
- **Mr. Giorgio Saccoccia**, European Space Agency (ESA), The Netherlands;
- **Mr. Christophe Bonhomme**, Centre National d'Etudes Spatiales (CNES), France;
- **Dr. Riheng Zheng**, China Aerospace Science & Industry Corporation (CASIC), China

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SOLID PROPULSION

A Solid Rocket Motor (SRM) has a solid fuel, a pyrotechnic material which integrates both oxidizer and fuel/binder. Once ignited, the propellant bore burns in parallel layers. High temperature combustion gases (up to 3600 K) create a self-standing pressure, these gases are ejected through nozzle to generate thrust. The predetermined thrust profile is given by bore geometry.
Several propellant families are existing (mainly double base or composite), their characteristics can be adjusted through the choice of ingredients.
A large range of SRM is possible, from small (some g) to huge (up to 500 t), and no preparation of maintenance is required during lifetime. These advantages are favorable for a lot of applications where a one-shot behavior is sufficient, such as: missiles (military), launchers boosters (very high thrust), separation fuses…
Advanced SRM technologies are developed for thrust modulation capability.

LIQUID PROPULSION

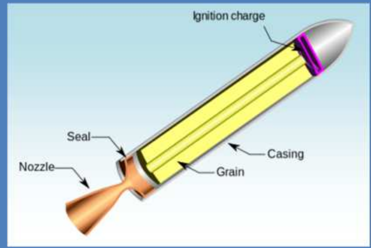
A Liquid Rocket Engine (LRE) uses generally two separate liquid propellants, the oxidizer and the reducer. When it is liquid at ambient temperature, the propellant is called storable, when it needs to be cooled to be liquid for storage it is called cryogenic propellant.(some time down to -255°C). Many liquid couples can be used such as Oxygen & Kerosene, Oxygen & Hydrogen or Nitrogen tetroxide & Monomethyl hydrazine. The performance of the LRE strongly depends on the chosen oxidizer & reducer couple, on the combustion process but also on the engine cycle divided into two main families: pressure fed (tanks pressurization) or pump fed. A Liquid Rocket Engine is suitable when high performance rather than high thrust (compared to solid propulsion) or when re ignition engine functionalities are needed. LRE existing applications covers rocket propulsion and also orbital propulsion such as satellite or orbital vehicles. Reusability and thrust modulation capacities are also inherent to liquid propulsion.

HYBRID PROPULSION

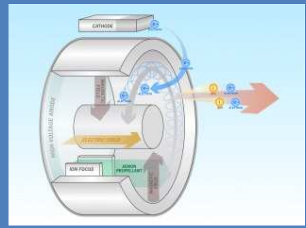
A Hybrid Rocket Engine (HRE) uses generally a liquid oxidizer such as liquid oxygen, hydrogen peroxide or nitrous oxide, and a solid fuel such as HTPB or paraffin. The solid fuel grain is integrated in a combustion chamber, equipped with a nozzle.
Liquid oxidizer is spread in the combustion chamber through an injector. An ignition is needed; after the fuel surface burns in parallel layer and generates thrust like a solid propellant motor.
HRE can modulate thrust level by tuning oxidizer flow rate, or even stop/restart. Other advantages are simplicity, high thrust level and non-pyrotechnic materials. A large range of applications is theoretically possible such as boosters, upper stages, landers, but maturity level is still low due to some drawbacks such as low burning rates and instabilities.
A lot of research & development works are ongoing to improve this maturity.

INTRODUCTION TO SPACE PROPULSION

Propulsion is a core need for astronautic activities, propulsion delivers the energy to reach space and to move spacecraft. This document provides some basics in order to support C4 sessions attendance.

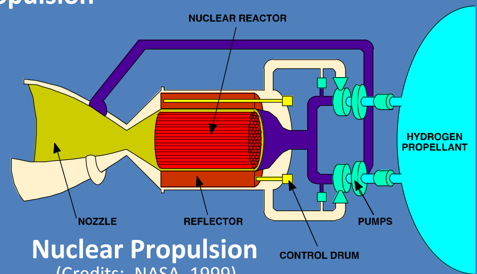


Solid Propulsion
(Credits: Wikipedia, 2017)

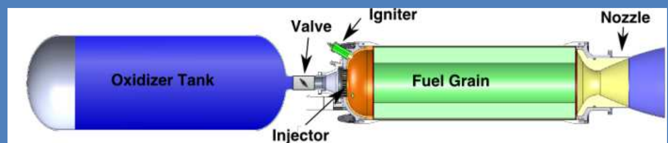


Electric Propulsion
(Credits: Georgia Tech)

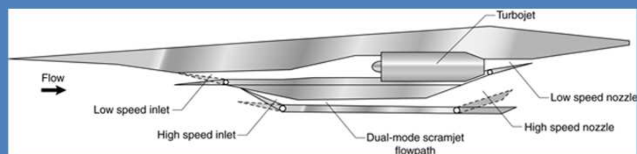
Liquid Propulsion (Credits: via Wikipedia Commons)



Nuclear Propulsion
(Credits: NASA, 1999)



Hybrid Propulsion (Credits: Jonny Dyer)



Turbine-Based Combined Cycle (TBCC) Engine
(Credits: Albertson, et al, 2006)

ELECTRIC PROPULSION

Electric Propulsion (EP) is used onboard spacecraft to perform a variety of maneuvers in space. Electricity as a source of energy is usually provided by solar panels, to ionize and accelerate the propellant (usually a gas). Power and gas have to be controlled by special units. Unlike Chemical Propulsion (CP), EP provides low thrust (< 1 N) but allows, through very high specific impulse, to reduce very significantly (up to 10 times) the mass of propellant needed for similar maneuvers. Today EP is a mature and widely used technology on communication satellites for orbital corrections, on spacecraft for the exploration of the solar system and is considered a promising technology for enabling the "new space" constellations. EP may be subdivided in three families based on type of plasma acceleration mechanisms: electrothermal, electromagnetic and electrostatic. Three electrostatic technologies have been developed particularly: Hall Effect Thrusters (HET), Gridded Ion Engines (GIE) and HEMP Thruster (HEMP-T).

NUCLEAR PROPULSION

Nuclear Propulsion covers a number of different concepts and technologies, all of which utilize nuclear reactions as the principal source of energy to produce thrust. The two nearest-term technologies are Nuclear Electric Propulsion (NEP) and Nuclear Thermal Propulsion (NTP). NEP is a form of electric propulsion in which an onboard nuclear powerplant supplies the electrical power to run either conventional or advanced electric thrusters. NTP operates similarly to a traditional chemical rocket by producing thrust via expansion of heated propellant through a converging/diverging nozzle. In this case of NTP, the propellant (typically hydrogen) is heated as it flows through the core of a high-temperature nuclear reactor. More advanced forms of Nuclear Propulsion include concepts that would directly utilize the energetic products from fission, fusion, and other nuclear processes to produce thrust.

HYPERSONIC & COMBINED CYCLE PROPULSION

Hypersonic and Combined Cycle Propulsion systems utilize ramjets, scramjets, turbojets and/or rockets together to enable air-breathing propulsion across a broad range of flight speeds and Mach numbers. Ramjets are most efficient between Mach numbers of 3 and 5, while at flight speeds greater than Mach 5 (hypersonic speed regime), ramjets employing supersonic combustion (scramjets) are most efficient. Accelerating a vehicle to where ramjet, followed by scramjet operation can occur is achieved by means of a turbojet or rocket. These are referred to as turbine-based and rocket-based combined cycles, respectively. Compared to conventional rockets, these combined cycle engines offer significantly higher effective specific impulse for space access to low earth orbit. They also offer more robust structural mass fractions, increased reusability (especially for turbine-based cycles), better payload fractions, and the operational flexibility of conventional aircraft.